Method of Loci and the Aging Mind: How a Visuospatial Mnemonic Device May Help Prevent Sub-Clinical, Age-Related Memory Decline

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1 author:

Simone T Conde
Boston College, USA

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Simone Conde

Boston College

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Abstract

Age-related memory decline is a natural occurrence in aging, but in some instances, older individuals will experience enough memory loss that they can be classified as having Mild Cognitive Impairment (MCI); this diagnosis is considered to be the second step along the spectrum of cognitive decline that extends into Alzheimer's Disease. Memory athletes who are renown for their abilities to process and retain remarkable amounts of information almost exclusively utilize a memory technique known as Method of Loci (MoL). MoL is effective for assisting in memorization for those with healthy memories because, in addition to utilizing brain areas traditionally implicated in memory formation, the method also utilizes areas associated with visuospatial relations and tasks. The same regions activated and strengthened by the MoL are ones that experience functional decay with age and in patients of mild and major cognitive impairment disorders. Because of this, I propose that instruction in MoL should become a standard practice at all levels of education and in treatments for cognitive impairment disorders in order to delay the progression of age-related memory decline and MCI.

Keywords: Method of Loci, MoL, memory, age-related memory decline, Mild Cognitive Impairment

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Memory loss attributable to aging is a prevalent concern since there is a substantial population of aging individuals ages 60 and over (United States Census Bureau, 2016). Many senior citizens and elderly individuals express annoyance as they recognize their developing inability to remember names, events, phone numbers, and similar pieces of information that are not very deeply encoded in their memories. It is therefore not uncommon to see members of these groups engaging in brain training through puzzles, handicrafting, reading, and other similar activities to maintain cognitive abilities. Research has found that training in the use of mnemonic devices can improve memory in healthy adults**.** The method of loci, a mnemonic technique used by world memory champions, is an ideal cognitive exercise to combat the natural process of memory decline characteristic of aging. The method of loci not only employs brain regions involved in memory, but also the regions that contribute to vision and spatial perception. By exercising the aging brain with the method of loci, we may be able to slow down the progression of memory decline that occurs naturally with aging, and therefore attenuate the more severe neurocognitive decline disorders such as dementia and Alzheimer disease if and when older individuals are at risk for them.

This practice takes advantage of neuroplasticity in the adult brain by strengthening connections in the very regions implicated in age-related memory decline in order to improve episodic and working memories, the two types of memory that are quickest to decline with age. Delaying age-related memory loss with daily mental exercise using method of loci may improve the quality of life for individuals who feel emotional distress towards short-term and episodic/autobiographical memory, and for those who face progression into a neurocognitive disorder as they age. Not all individuals who experience age-related memory decline are destined for more severe disorders, but for those who are, mental exercise with the Method of Loci may temporarily improve their quality of life while they adapt and/or fall victim to more severe neurocognitive changes.

The reason the aging adult brain is able to respond to the method of loci or any other form of cognitive training is a property of neuroplasticity, which only recently has been understood as a trait of even a cognitively impaired, aging brain (Belleville et al., 2011). Neuroplasticity is the feature of the human brain that allows synaptic connections to change over an individual's lifetime in response to damage, deficits, or learning-related changes in brain activity. Cognitive responsibilities for sensation, voluntary movement, recall, and many other functions can be re-allocated, or pre-existing circuits can be strengthened through experience and learning by means of neuroplastic changes. Brain changes due to plasticity can be observed through functional magnetic resonance imaging (fMRI), and sometimes with MRI if the changes are structural (Markham & Greenough, 2004; Fjell, McEvoy, Holland, Dale, & Walhovd, 2014). Neurogenesis does not occur in the adult human brain (save for the dentate gyrus of the hippocampus and the olfactory bulbs), and so the proliferation of astrocytes and oligodendrocyte processes are examples of plastic changes observable through structural imaging (Markham & Greenough, 2004). Changes in synaptic connections between neurons are mainly responsible for plastic changes; this can include the reshaping of dendritic spines and increasing in postsynaptic density. Dendritic spine turnover as a result of rich sensory experience was observed in mice (Trachtenburg et. al., 2002, as cited in Markham & Greenough, 2004). Cerebrovasculature can proliferate as a plastic response to learning as well (Markham & Greenough, 2004). I will be discussing how taking advantage of neuroplasticity in aging individuals to slow the progression of age-related memory decline and the next least-aggressive age-related memory decline attributed to Mild Cognitive Impairment, a non-psychiatric diagnosis of cognitive impairment and memory loss just slightly more severe than what is normal for aging that indicates prodromal dementia.

Discussion

Research exploring the neurophysiology of superior memorizers provides evidence that interventional use of the MoL could be beneficial for slowing down the progression of non-clinical levels of memory loss. The Default Mode Network of the brain may be the key to understanding the efficacy of MoL in strengthening connections between brain structures that contribute to the functioning of episodic and working memories.

What is Age-Associated Memory Impairment, and Who Gets It?

Age-associated memory impairment is a common occurrence among aging adults, and while many individuals can perceive this low level of memory decline, standardized memory tests can also reveal the presence of this phenomenon; individuals with age-related memory loss will score lower than young adults on objective memory performance measures (Small, 2002). Age-related memory decline is commonly noticed by the individual and his/her family members and friends as their losing things and forgetting names (Fan, 2015). The most rapid losses in memory due to old age are in episodic memory and working memory, while semantic memory and procedural memory are much more resilient (Craik, 2008). Froger et al. found that MCI patients have difficulties with encoding episodic memories, mainly in initiating encoding and retrieval strategies (as cited in Bellville et. al, 2011). Memory decline in short-term and episodic memories are highly sensitive to the aging process (Kinugawa et. al 2013, referenced in Weintruab-Youdkes, Prisant, Ben-Israel & Merims, 2015).

Diagnosis of Age-Related Memory Decline and MCI

Age-associated memory impairment is often confused with Mild Cognitive Impairment (MCI). Mild cognitive impairment is more severe in that it puts individuals at higher risk for developing Alzheimer Disease, whereas general age-related memory decline is very common and is generally not a basis for concern (Bormans, Roe & De Wachter, 2016). Neither condition has a set of DSM-5 criteria, but MCI can be diagnosed by physician discretion, and is often confirmed by low scores on objective memory tests. However, the prevalence of age-related memory changes is large enough that exploration into methods of preventing or reversing memory loss would benefit a great number of individuals. Age-related memory decline and MCI are considered stages of the spectral progression to dementia and even Alzheimer's from normal aging (Lenga & Levine, 2014). At ages above 65 years, the presence of illnesses that increase risk for dementia (a DSM-5 Major Neurocognitive Disorder) such as stroke, diabetes, and Parkinsons, and a family history of dementia are all automatic risk factors that should incite a medical professional to be cautious of changes in memory in a patient (Small, 2002). Risk for a neurocognitive disorder is not exclusive to those with genetic predispositions for these illnesses; early adulthood head injuries can lead to memory impairments later in life, supporting the idea that development of a disorder that impairs memory is affected by environment as well (Small, 2002). The pervasiveness of neurocognitive disorders is why measures to delay onset of memory impairment should be developed and standardized for widespread use.

What is the Method of Loci, and What is it Used For?

The Method of Loci (MoL) is a mnemonic device developed by ancient Greek and Roman rhetoricians to remember lengthy speeches (Thomas, 2014). It involves pairing elements of a list of numbers, images, symbols, or events to locations within a mental representation of a familiar location/building (Fan, 2015). During recall, an individual using MoL imagines navigating this “mind palace” (the name that the Greeks and Romans used for the mental representation of the building) and gazes upon the features (the *loci*; Latin, pl. of *locus*, meaning “fixed position”) of the building or location that serve as retrieval cues in the predetermined order. The method of loci is one of the most effective mnemonic devices because it requires both spatial and associative memory processes; other devices use one or the other. MoL has been found to significantly increase activity in the medial temporal lobe, which has been implicated in episodic and spatial memory (Fjell et. al, 2016; Fellner et. al, 2016). For this reason, MoL is used most widely by individuals who compete in memory championships. The majority of world memory champions use this device to memorize astounding units of information, and practice applying this method to random or unrelated strings of data with the same frequency and intensity with which athletes practice techniques of their sports (Dresler et. al, 2017; Mallow, Bernarding, Luchtmann, Bethmann & Brechmann, 2015). These individuals who are acknowledged on both national and global platforms for their memories are often referred to as superior memorizers (SMs). Superior memorizers do not appear to have any advantages with regards to superior intellect or brain physiology; their incredibly skills can be accredited to years of practice with mnemonic techniques, the most popular of which being MoL.

In fMRI studies, SMs show greater levels of cortical and subcortical activation when compared to non-superior memorizers in a classic fMRI study by Macguire and colleagues investigating the distinguishing neurophysiological features of the SM brain (Maguire, Valentine, Wilding & Kapur, 2003). The MoL can be used by anyone for a variety of purposes, including learning foreign languages. During the TEDXTeen talk which inspired this paper, Tim Doner (2014) explains that he has used the Method of Loci, among many other techniques, to learn 20 foreign languages. He then demonstrates the Method of Loci by recalling 8 out of 10 Japanese words along a path that he had created with his mental representation of Union Square in his home town of New York City. The MoL can be applied to any free recall (e.g. vocabulary for a new language) or order-sensitive recall task, since the pathway throughout the architectural/geographic space requires a specifically ordered pathway to ensure all the *loci* are visualized. Doner did not need to have the vocabulary terms memorized in a certain order, but the order of the distinct locations (e.g. a fountain) with which he paired the words allowed him to establish a repeatable path. This technique is straightforward and requires only some training in properly executing the technique, meaning that anyone who has the mental capacity can use this method to encode any information they please. In general, mnemonics have been found to be effective in memory remediation in the elderly and, interestingly, in special needs populations as well (Maguire, Valentine, Wilding & Kapur, 2003). The method of loci is a superior mnemonic device due to its accessibility to individuals of all intelligence levels and memory capacities, and to its ability to engage areas of the brain that are normally underutilized in semantic memory consolidation.

Studies Regarding Efficacy of MoL for Non-Therapeutic Memory Purposes

Multiple research studies support efficacy of MoL in non-therapeutic purposes. In a 2017 study by Dresler and colleagues, 23 successful memory athletes and 51 mnemonic-naïve healthy controls were tested for their cranial responses to encoding novel information with the help of mnemonics. Mnemonic training elicited changes in the brain that led controls' brains to exhibit network connectivity patterns similar to those that distinguish memory athletes. This implies that superior memory can be elicited in anyone and is not a product of inherent brain structures or intelligence levels. Superior memory appears to be supported by changes in functional connectivity between brain structures rather than growth isolated to singular structures (Figure 1). In the widely-referenced study by Macguire, Valentine, Wilding, and Kapur (2003), performance in memory tasks was compared between 10 superior memorizers (SMs) and 10 mnemonic-naïve controls. The study controlled for possible differences in brain activity in SMs that would allow them to successfully learn a greater amount of information by presenting three types of memorizable stimuli: numbers, faces, and snowflakes. These stimuli were expected to elicit large, moderate, and no differences, respectively, in cortical activity between SMs and HCs. The researchers' hypothesis was supported in that the smallest differences between groups occurred in the snowflake memorization task as expected; snowflakes are difficult to verbalize and are not a usual object of memorization for memory athletes as digits are. Performance was expected to be comparable between groups for the snowflake stimuli, as neither had any advantage in memorizing details of a snowflake. Even when performance between SMs and HCs was matched, SMs showed higher levels of brain activity. Nine of the ten of the SMs admitted to using MoL for some or all of the tasks (all 10 used mnemonics), which can explain why these areas of heightened activity were ones often associated with long-term memory, spatial memory, and navigation.

Superior memorizers have also been found to be able to recall more words at a faster rate than mnemonic-naïve individuals, according to a study by a German research team that compared the performance of SMs and controls; extensive practice with MoL gave SMs an advantage of memory efficiency – units of information over time (Mallow, Bernarding, Luchtmann, Bethmann & Brechmann, 2015). In another study by Kondo and colleagues (2005), subjects were asked to encode and recall images before and after instruction in the MoL; functional brain activity was assessed using fMRI during encoding, interference, silent recall, and baseline fixation tasks. Oral recall and item recognition tasks were conducted in another room following scanning. The study found significant differences between oral recall scores before and after instruction in MoL, indicating the efficacy of MoL as a mnemonic device. For further explanation on neurological findings of these and more studies regarding the MoL, see Table 1.

Neuroplasticity in Age-Related Memory Decline

As previously mentioned, adult brains can experience plastic changes, even in old age. However, there is still much to learn about how we can induce neuroplastic changes among those who are at risk for memory loss due to old age. Adults with mild cognitive impairment showed training-related increases in activation of frontal, temporal, and parietal brain areas after undergoing episodic memory training using mnemonics (Belleville et. al, 2011). To explore elderly neuroplasticity with regards to MoL, a 2015 study used modified version of MoL was used at an adult day care center as a group/social mental exercise activity. Neurocognitive examinations of the participants showed improvement not only in verbal memory over time, but also in global cognitive function (Weintruab-Youdkes, Prisant, Ben-Israel & Merims, 2015). Plasticity has also been indirectly measured through cortical thickness before and after a Method of Loci-based memory training program in healthy middle-aged and elderly individuals. Memory training involved eight weeks of training consisting of 1-hour class room sessions and four days of homework exercises. Participants in memory training were presented 10-word, 20-word, and 30-word lists of items in both their native Norwegian and in other languages; they had to successfully learn shorter lists in order to move on to longer lists. The tasks involved brief presentation of the word list, reading of a short interference (distractor) text, and then recall of the words. Home exercises involved using the MoL to memorize names and faces. Review of

MRI pre-trial and post-trial scans of memory-training group members (n=22, M_{age}= 61.3) and control group members (n=20, M_{age}=60.3) found significant increases in grey cortical matter in the left orbitofrontal cortex, the right lateral orbitofrontal cortex, and the right fusiform cortex, all areas of association cortex that are involved in higher-level cognitive functions. Participants in the training group showed significant improvement in the source memory task, and while participants in the control group also achieved improvement as a whole, they did not achieve statistically significant improvements. As age of the individuals in the training group increased, the improvement in cortical thickening was decreasingly remarkable. This study supported the idea that seniors are capable of neuroplastic changes in grey matter, the atrophy of which is often associated with aging. Increase in grey matter, which is visible in the structural MRI scans, is the result of increases in neuron soma size, increase in number of glial cells, and increased capillary size (Trachtenberg et al., 2002, as cited in Envig et al., 2010).

Why Method of Loci Has Potential as a Preventative Measure

Aging inevitably involves a variety of changes to brain regions, one of which is the Default Mode Network (DMN). The DMN is a network of structures that supports wakeful cognitive inactivity and passive or introspective activity. Aging has been associated with marked losses in long-range functional connectivity density in the DMN (Tomasi & Volkow, 2012). Andrews-Hanna, Smallwood, and Spreng (2014) devised a clustering of DMN regions/structures, one of which is the medial temporal subsystem comprised of retrosplenial cortex (RSC), parahippocampal cortex, posterior inferior parietal lobe, and ventromedial prefrontal cortex (vmPFC). The authors' meta analyses reveal high correspondence between elements of this medial temporal subsystem and autobiographical thought, episodic memory, and contextual retrieval. A combined structural MRI and fMRI study assessing DMN activity in healthy aging and MCI revealed impairment in DMN among amnesic type MCI patients (Bai et al., 2008).

A large-scale network homologous to the human DMN has been observed in rats through fMRI research. Aged rats with memory impairment (determined by performance on a Morris water maze) showed age-related changes in resting state functional connectivity (rs-FC) between the RSC and the posterior cingulate cortex (PCC) (Ash et al., 2016). However, no significant differences were found between young rats and aged rats determined to have unimpaired memories, indicating a relationship between RSC/PCC connective strength and memory. A review conducted by Hafkemeijer and colleagues found that most studies showed more instances of decreases in DMN functional connectivity and task-induced deactivations along a continuum of memory loss from normal, healthy aging to MCI (Hafkemeijer, van der Grond, & Rombouts, 2011). DMN connections naturally decrease with age, even in healthy adults, particularly observable as decreased overall connectivity between medial prefrontal cortex (mPFC), PCC, and lateral parietal cortex. However, MCI patients experience both functional connectivity changes and regional deactivations within the DMN. For example, MCI patients showed an absence of functional connections between the hippocampus- a structure essential for memory formation- and the PCC which were present in healthy controls; MCI patients also showed decreased functional connectivity between prefrontal, frontal, and cingulate regions. These findings were true even after grey matter atrophy (a result of normal aging) was controlled for.

Method of Loci seems promising as a cognitive exercise to help combat age-related memory decline and mild cognitive impairment because this procedure strengthens connections between and within the very brain structures that are believed to lose functional connectivity during aging. The retrosplenial cortex, parahippocampal cortex, and other parietal, temporal, and frontal areas have been implicated in studies assessing the effects of aging on the DMN, *and* in studies assessing the neuroplastic changes associated with training in the Method of Loci (see Table 1, column "Summary of neuroimaging findings"). There is potential for MoL to be used as a preventative and therapeutic measure to combat the loss of functional connectivity in DMN structures that play roles in working and episodic memory, which usually see decline as a result of aging and age-related memory impairment.

Limitations

The most egregious issue with using the MoL to improve the memories of older adults is the issue of noncompliance. Meta-analysis conducted by Verhagen and Marcoen (1996) indicates that young adults tend to benefit more from instruction in the Method of Loci than older adults do. While the elderly have shown significant improvements in studies that require instruction in the MoL, the younger research participants seem to hold an advantage due to their age-related mental swiftness, mental status (also colloquially known as "brain age"), large working memory capacities, good episodic memories, and strong abilities in both logical reasoning and spatial orientation. All of these features are understood to decline with age. In addition to these inherent cognitive differences, noncompliance among elderly participants is an issue; elderly participants may either apply the MoL incorrectly (despite having received adequate training in it prior to memorization tasks) or do not use it at all and instead employ other less-effective but personally preferred mnemonic techniques. This presents two highly significant issues. Firstly, current or future studies which assess improvements in cognition after using training in MoL but do **not** ask follow-up questions about how well/often the participants followed correct technique could explain differences between older and younger participants' data with older-individual noncompliance. Secondly, if middle-aged to elderly adults have a proclivity to give up easily when trying to employ MoL, implications for its promise as a therapeutic device for memory are weak. In the follow-up study conducted by Verhaeghen and Marcoen (1996) which tested younger and older adult groups for general memory factors (their speed of mental processing, verbal working memory, and visual working memory) and specific memory factors (spatial ability, vividness of imagery, and associative memory), compliance with the MoL was reliably correlated with age; a significant portion of the older participants did not comply with study instructions at all times for the ordered recall task (which is essentially a task of following the path through one's orderly mental route and naming the items paired with *loci*). The only variable that reliably distinguished the groups from each other was age, as all participants indicated similar hours of home study. Of the MoL users, the older participants studied more lists for more time than younger participants, meaning that differences in scores *between* MoL users cannot be associated with less study time engaged by the elderly participants, and must be due to inherent, age-related cognitive differences. Decrease in effectiveness of MoL in older adults as well as the issue of noncompliance are discouraging. However, the Method of Loci appears to be our strongest tool for increasing memory capacity in older adults, based on current research supporting its efficacy for increasing memory efficiency and bolstering connections in memory-related circuits. When it *is* used properly, neuroplastic functional and structural changes have been and are observed in elderly adults. If instruction is conducted while an individual is still a young or middle-aged adult, we may be able to avoid these issues of age-dependent cognitive limitations and noncompliance while still reaping the benefits of training in the Method of Loci.

Conclusions

Years of research have implied that memory can reliably be improved using method of loci. A variety of brain regions have been implicated in the neuroplastic changes associated with training in Method of Loci and increase in memory efficiency when tested after training. The majority of these regions are in attentive, memory, and spatial awareness networks of the brain. The DMN and retrosplenial cortex seem to carry the greatest number of implications among the current research (see Table 1). However, further research is needed in plastic changes over time in the aging brain due to practice with the method of loci. Longitudinal studies would be most beneficial for revealing the long-term effects of both single-trial or long-term Method of Loci training in middle-aged and elderly individuals. I believe that instruction in the Method of Loci should become a standard practice in adult day care centers for patients of dementia, Alzheimer's, and other memory-loss-related diseases, given its efficacy for improving cognition, working memory, and episodic memory. Ideally, educators and neuropsychologists would develop a curriculum for teaching and practicing method of loci in the classroom as early in a child's education as possible. The MoL would enrich the educational experience, and provide students with a tool they may use throughout their educational experiences and beyond. Neuropsychologists and developmental psychologists need to determine the earliest age at which students would be able to understand and follow instructions for engaging in the mnemonic. Logically, the earlier the Method of Loci is implemented in elementary curriculum, the greater the protective effects on memory will be; spending years utilizing this methodology for consolidating semantic memory has the potential of encouraging superior levels of connectivity in the developing brain. The development of a standardized therapeutic MoL training protocol may serve clinicians, researchers, therapists, and anyone else involved in the treatment of psychiatric, neurodevelopmental, and neurocognitive disorders. Implementation of MoL in schools, memory improvement programs, and in elderly day-care centers would at least be a prudent protective measure against the development of age-related memory loss; the real possibilities for the use of the technique seem to be quite vast, as memory is important to who we are, what we do, and how we think.

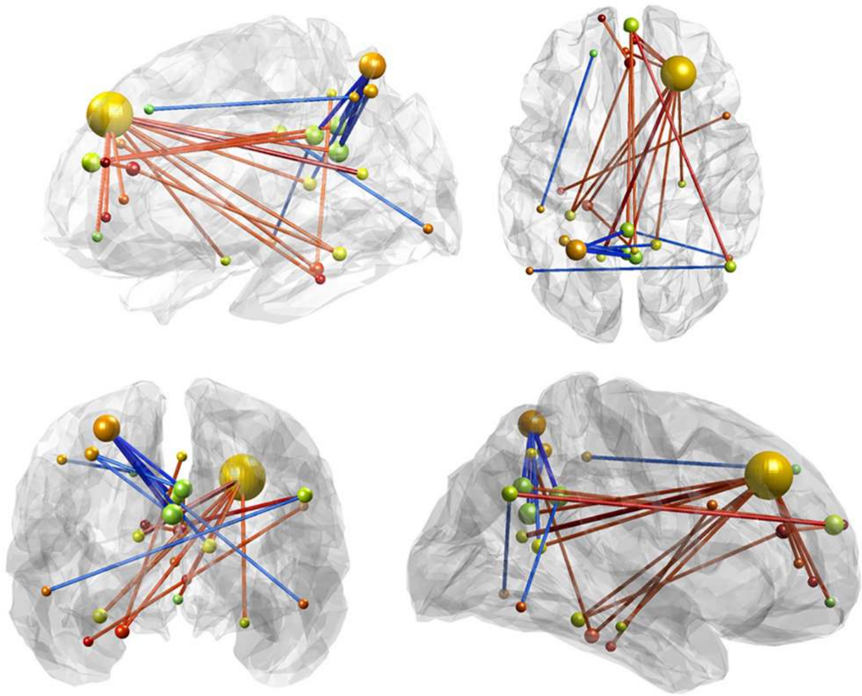

Figure 1. The Top 1% of Differential Connections between Memory Athletes and Matched Controls (taken from Dresler et al., 2017). The red lines between spherical regions of interest indicate pathways which have stronger functional connections in memory athletes (individuals who train in MoL on a regular basis) than in healthy, age-, sex-, handedness-, and intelligence-matched controls. Most of these reinforced connections exist between the frontal lobe and parietal lobe or the frontal lobe and the temporal lobe, which is consistent with the findings of many studies assessing neuroplastic changes in response to MoL training. Blue lines indicate connections that were found to be stronger in mnemonic-naïve controls; these are fewer in number than the red lines, indicating that memory training generally contributes to the strengthening of functional/neural connections- likely those utilized in memory encoding and consolidation.

Study	*Defining Keywords**	*Samples (N, M for age [years]±SD,]and* [F/M]*#)*	*Design and format of intervention/trial*	*Control Condition or Population*	*Summary of main findings*	*Summary of neuroimaging findings*
Dresler, et al., 2017	Resting state; brain networks; dynamics	23 world memory champions (*M*=28±8.6, 9F/14M and 51 mnemonic-naïve controls (*M*=24±3.0, 51M)	**fMRI**; Two fMRI sessions over 6-week interval; in each session, participants memorized 72 words, free recall tested after 20 min and 24 hrs. Pseudo-randomly assigned to either 6 weeks of MoL training or control condition.	n-back working memory training (active control), or no training at all (passive control)	Significant improvement in memory performance in mnemonic training group in second experimental session; persistence of group effect at four-month follow up test f words used in first trial.	Training effects generated connectivity similar to that in memory athletes in MPFC, DLPFC, left pHG, bilateral retrosplenial cortex, posterior cingulate, and right angular gyrus.
Kondo et al., 2004	Brain; fMRI	14 healthy males (*M*=22.3, age [range 20-26], 14M)	**fMRI**; Encoding, interference, recall, and baseline fixation tasks were given during fMRI scan, followed by oral recall and item recognition tasks in a new room; sets of these tasks were performed before and after instruction in MoL.		Significant difference between recall scores before and after instruction; 11/14 participants admitted to using MoL during the post-training phase.	Changes in brain activation pattern associated with use of MoL found in left fusiform and lingual areas, bilateral prefrontal, posterior pHG, retrosplenial cortex, precuneus.
Maguire, Valentine, Wilding, Kapur, 2003		10 superior memorizers (M=33.9±9.33, 10M) and 10 control subjects (*M*=33.1±7.90, 10M)	**fMRI**; Participants were asked to memorize and recall three-digit numbers, faces, and snowflakes and their orders in sequences.	Mnemonic-naïve control participants	Superior memory is not driven by structural brain differences or superior intellect. SMs scored higher on recall even when performance between SMs and controls was matched.	Superior memory associated with the preferential engagement of medial parietal cortex, retrosplenial cortex, and the right posterior hippocampus.
Envig et al., 2010	Brain; plasticity; aging; imaging	22 participants in the memory training group (*M*=61.3±9.4, 12F/10M) and 20 participants in the control group (*M*=60.3±9.1, 11F/9M)	**MRI**; Participants engaged in an 8 week MoL training program meant to improve verbal source memory both in a class setting and with homework; memory trainers were asked to memorize lists of 10, 20, and 30 words in controlled amounts of time.	Control participants did not engage in any memory training and proceeded with life normally.	Memory assessment scores for MoL trainers were significantly improved from their scores at baseline; those who did not train with MoL failed to see significant improvements.	Improvements in source memory were related positively with cortical thickening in the left and right lateral orbitofrontal cortices, as well as the right fusiform area.

Belleville, Clément, Mellah, Gilbert, Fontaine & Gauthier, 2011	Mild cognitive impairment; Alzheimer's disease; neuroimaging ; functional MRI; brain plasticity	15 participants with mild cognitive impairment (*M*=70.13±7.34, 11F/4M) and 15 healthy controls (*M*=70±7.26, 10F/5M)	**fMRI**; Participants in both groups engaged in 6 weeks of small-group training in mnemonic techniques, including MoL. Both before and after training, participants tested on free recall skills. During neuroimaging, participants asked to perform encoding and retrieval tasks.		Both the healthy and MCI participants improved their recall scores after mnemonic training; Group effect was significant and evident by the greater number of recalled words among healthy individuals.	Healthy adults showed reduced activity in frontal, temporal, and parietal regions, while MCI adults showed increased activity in these regions. Healthy controls experienced significant training-related increases in activation in the right hippocampus during retrieval tasks, but MCI adults did not experience training-related changes in the hippocampus.
Mallow, Bernarding, Luchtmann , Bethmann & Brechmann , 2015	Superior memorizers, mental navigation, encoding, recall	7 superior memorizers (*N*=32.3, 2F/5M) and 7 mnemonic-naïve controls (*N*=25.1, 3F/4M)	**fMRI;** Four-block trial scheme. Encoding: memorization of a matrix of digits. Attention task: indicate via button whether number in new matrix was even and number of dashes surrounding digit equaled 2. Recall: Verbal recall of original matrix. Rest: Recite alphabet in silence.	Mnemonic-naïve control participants	Superior memorizers showed better recall than than mnemonic-naïve participants, and in significantly faster time.	During encoding, SM's showed significantly greater activation in left secondary visual areas, left med. Superior parietal, and left middle temporal gyrus. Strong lateralization of retrosplenial cortex and posterior parahippocampal gyrus to left hemisphere also observed.

Table 1. Findings of Studies Regarding Efficacy of MoL for Non-Therapeutic Memory Purposes. This table is the author's own, and includes six studies found through the Boston College Libraries search engine and NCBI's PubMed.gov. Defining keywords column excludes the following list of terms due to overlap between studies: method of loci, MoL, memory, mnemonic, cognitive training, memory training, and training.

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